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Appendix A - Summary of Sampling and Analysis Activities

This appendix describes the surface water, sediment, soil, and biota investigations designed to assess the nature and extent as well as the fate and transport of hazardous constituents in the Housatonic River Rest of River area. The investigations cover a time span of more than 20 years, and include sampling conducted as part of the United States Environmental Protection Agency's (EPA's) Supplemental Investigation (SI). The various efforts are discussed throughout this appendix and are organized by medium to present a comprehensive review of medium-specific data sources. Program descriptions and results of collection activities were compiled from available literature sources and supplemented, when necessary, by the databases developed by the General Electric Company (GE) and EPA (November release).

1.1 Surface Water Investigations

Numerous surface water investigations have been conducted since the late 1970s to study relevant surface water characteristics as well as the presence, extent, and transport of polychlorinated biphenyls (PCBs) and other hazardous constituents in the water column of the Housatonic River.

1.1.1 Ambient PCB Trend Monitoring

Ambient PCB trend monitoring (monthly water column sampling, low-flow, and high-flow sampling) of the Housatonic River water column has been performed as part of several investigations to determine the presence, extent, and/or transport of PCBs and other hazardous constituents in the water column and to characterize the general water quality.

Beginning in 1978, the Connecticut Agricultural Experiment Station (CAES), in conjunction with the Connecticut Department of Environmental Protection (CDEP) and United States Geological Survey (USGS), performed water column monitoring at USGS gaging stations at Great Barrington, Massachusetts and Falls Village and Gaylordsville, Connecticut. Depth-integrated suspended sediment samples were collected daily during an 18-month period between April 1979 and September 1980, resulting in the collection of 549 samples from each location. In addition, water column samples were collected as frequently as hourly during five high-flow events (October and November 1979 and March, April, and June 1980) and analyzed for total and dissolved PCBs. At Great Barrington and Falls Village, 14 high-flow water column samples were collected, while 13 samples were collected at Gaylordsville. In conjunction with sampling for PCB during high-flow events, suspended sediment measurements were made during the November 1979 and March, April, and June 1980 high-flow events at Great Barrington (seven samples); November 1979 and March and April 1980 high-flow events at Falls Village (six samples); and November 1979 and March 1980 high-flow events at Gaylordsville (seven samples) (Frink et al., 1982).

Following the CAES investigations, Stewart Laboratories, Inc. (Stewart) conducted an analysis of surface water PCB concentrations at three locations on the Housatonic River (Schweitzer/Lenoxdale, Division Street, and Andrus Road Bridges) during three short-term transport investigations conducted in February, March, and April 1980. The February 1980 sampling event was conducted during "typical winter background conditions" (Stewart, 1982). The March 1980 sampling event occurred at higher stream flow rates during a snowmelt period, and the April 1980 investigation was conducted during a precipitation storm-flow event. Sampling activities conducted during the three flow events resulted in the collection of 40 depth-integrated water column samples for total suspended solids (TSS) and total and dissolved PCB analyses (Stewart, 1982).

Subsequently, in cooperation with the USGS, CDEP performed water column monitoring during high-flow events between June 1984 and September 1988 at five USGS gaging stations (Great Barrington and Ashley Falls, Massachusetts, and Canaan, Kent, and Falls Village, Connecticut). A total of 32 water column composite samples were analyzed for TSS and total and dissolved PCBs (Lawler, Matusky and Skelly Engineers [LMS], 1991).

Between 1989 and 1991, Blasland & Bouck collected water column samples on approximately a monthly basis at six locations (Dawes Avenue Bridge, New Lenox Road Bridge, Woods Pond Headwaters, Former Housatonic Street Abutments, Schweitzer/Lenoxdale Bridge, and Division Street Bridge) on the Housatonic River. A total of 123 water column samples (including duplicate samples) were collected during the investigation and submitted for laboratory analysis. All 123 samples were analyzed for total and dissolved PCBs (one sample collected on February 6, 1992 at the Former Housatonic Street Abutments was only analyzed for total PCBs), while 77 samples were measured for total organic carbon (TOC). In addition, of the 123 samples analyzed for PCBs, 63 samples were also analyzed for chlorophyll *a* and TSS was measured in 118 samples. In addition, conventional water quality parameters (i.e., conductance, pH, and temperature) were measured upon collection in the field.

As part of the Housatonic River Massachusetts Contingency Plan (MCP) Supplemental Phase II Investigations, additional monthly water column samples were collected between 1996 and 1998 to fill apparent data gaps. Between March 1998 and February 1999, under the direction of the General Electric Company (GE), Blasland, Bouck & Lee, Inc. (BBL) instituted a bi-weekly sampling schedule. Monthly water column monitoring resumed in October 1999 and continued through October 2001. During the monthly monitoring, BBL collected surface water samples to provide PCB data upstream and downstream of the GE facility and more up-to-date surface water PCB data below Rising Pond. The remainder of this section provides a brief summary of the sampling activities carried out between 1996 and 2002.

1.1.1.1 1996 Sampling

BBL conducted monthly water column monitoring at the following 16 locations in 1996 (number in parentheses represents total number of samples collected):

- Hubbard Avenue Bridge (9)
- Newell Street Bridge (9)
- Newell Street Parking Lot Footbridge (9)
- Lyman Street Bridge (9)
- Elm Street Bridge (9)
- Dawes Avenue Bridge (9)
- Upstream of the Confluence with the Housatonic River (4)
- Holmes Road Bridge (9)
- Adjacent to Joseph Drive (14)
- Holmes Road Waste Water Treatment Plant (WWTP) (4)
- EPRI Facility (4)
- New Lenox Road Bridge (13)
- Headwaters to Woods Pond (10)
- Former Housatonic Street Abutments (10)
- Schweitzer/Lenoxdale Bridge (9)

- Division Street Bridge (10)

Surface water samples were collected as grab or depth-integrated (i.e., DH-76 sampler) samples on approximately a monthly basis. A total of 143 samples (including duplicates) were collected for laboratory analysis and analyzed for total PCBs. Of these 143 samples, 77 samples were also analyzed for dissolved PCBs, and TSS was measured in 106 samples.

In addition, sampling was conducted upstream and downstream of the Unkamet Brook Confluence to supplement the results of pre-1996 sampling events. Two surface water samples were collected (one upstream and one downstream) in December 1996. Samples were analyzed for total and dissolved PCBs.

1.1.1.2 1997 Sampling

BBL conducted monthly water column monitoring at the following 15 locations in 1997 (number in parentheses represents total number of samples collected):

- Hubbard Avenue Bridge (13)
- Newell Street Bridge (7)
- Newell Street Parking Lot Footbridge (8)
- Lyman Street Bridge (17)
- Elm Street Bridge (14)
- Dawes Avenue Bridge (12)
- Holmes Road Bridge (13)
- Adjacent to Joseph Drive (12)
- New Lenox Road Bridge (15)
- Headwaters to Woods Pond (12)
- Former Housatonic Street Abutments (15)
- Schweitzer/Lenoxdale Bridge (25)
- Division Street Bridge (14)
- Andrus Road Bridge (4)
- Bulls Bridge Dam (4)

Surface water samples were collected as grab or depth-integrated (i.e., DH-76 sampler) samples on approximately a monthly basis. A total of 185 samples (including duplicates) were collected for laboratory analysis and analyzed for total PCBs. Of these 185 samples, 138 samples were also analyzed for particulate organic carbon (POC), and chlorophyll *a* and TSS were measured in 165 samples.

1.1.1.3 1998 Sampling

BBL conducted monthly water column monitoring in January and February 1998 at the following 13 locations (number in parentheses represents total number of samples collected):

- Hubbard Avenue Bridge (2)
- Newell Street Bridge (2)
- Newell Street Parking Lot Footbridge (2)
- Lyman Street Bridge (4)

- Elm Street Bridge (2)
- Dawes Avenue Bridge (2)
- Holmes Road Bridge (2)
- Adjacent to Joseph Drive (2)
- New Lenox Road Bridge (2)
- Headwaters to Woods Pond (2)
- Former Housatonic Street Abutments (2)
- Schweitzer/Lenoxdale Bridge (2)
- Division Street Bridge (2)

A total of 28 grab samples (including duplicates) were collected for laboratory analysis and analyzed for total PCBs, POC, chlorophyll *a*, and TSS.

In March 1998, bi-weekly sampling was instituted; BBL collected water samples at the following seven locations (number in parentheses represents total number of samples):

- Hubbard Avenue Bridge (33)
- Dawes Avenue Bridge (20)
- Holmes Road Bridge (19)
- New Lenox Road Bridge (18)
- Headwaters to Woods Pond (18)
- Schweitzer/Lenoxdale Bridge (18)
- Division Street Bridge (18)

Surface water samples were collected as grab samples between March and June 1998 and as composite samples between July and December 1998. A total of 144 samples (including duplicates) were collected and analyzed for total PCBs, POC, chlorophyll *a*, and TSS. In addition, between November and December 1998 water conductance, temperature, and pH were measured in the field.

In addition, sampling was conducted upstream and downstream of the Unkamet Brook Confluence to supplement the results of previous sampling events. Five surface water samples were collected (three upstream and two downstream) during the May and December 1998 sampling events. Samples were analyzed for total and dissolved PCBs.

EPA conducted surface water sampling in August and October 1998, during which BBL obtained split samples. EPA collected samples at the following 16 locations (number in parentheses represents total number of samples):

- Housatonic Street Bridge Behind Crane & Co. (2)
- Hubbard Avenue Bridge (3)
- Upstream of the Unkamet Brook Confluence (2)
- Newell Street Bridge (2)
- Newell Street Parking Lot Footbridge (2)
- Lyman Street Bridge (3)
- Elm Street Bridge (2)
- West Branch Confluence (2)
- Holmes Road Bridge (2)
- Adjacent to Joseph Drive (2)

- Holmes Road WWTP (1)
- New Lenox Road Bridge (2)
- Headwaters to Woods Pond (2)
- Former Housatonic Street Abutments (2)
- Schweitzer/Lenoxdale Bridge (2)
- Division Street Bridge (2)

BBL obtained a total of 33 split samples for laboratory analysis. All 33 samples were analyzed for total PCBs, TSS, and chlorophyll *a*; 16 were analyzed for dissolved PCBs; and 17 were analyzed for POC. In addition, water temperature, conductance, and pH were measured during the October 1998 sampling.

1.1.1.4 1999 Sampling

BBL conducted bi-weekly water column monitoring between January and March 1999 and resumed monthly sampling in October 1999. Surface water samples were collected from the following seven locations (number in parentheses represents total number of samples):

- Hubbard Avenue Bridge (16)
- Dawes Avenue Bridge (8)
- Holmes Road Bridge (8)
- New Lenox Road Bridge (8)
- Headwaters to Woods Pond (7)
- Schweitzer/Lenoxdale Bridge (8)
- Division Street Bridge (7)

A total of 62 surface water samples (including duplicates) were collected and analyzed for total PCBs, POC, chlorophyll *a*, TSS, and water quality parameters (i.e., temperature, conductance and pH).

In addition, sampling was conducted upstream and downstream of the Unkamet Brook Confluence to supplement the results of previous sampling events. A total of four surface water samples were collected (two upstream and two downstream) during sampling events in April and October 1999. These samples were analyzed for total and dissolved PCBs.

Between March and September 1999, BBL obtained split samples from EPA sampling efforts conducted at the following 17 locations (number in parentheses represents total number of samples collected):

- Housatonic Street Bridge Behind Crane & Co. (7)
- Hubbard Avenue Bridge (7)
- Upstream of the Unkamet Brook Confluence (7)
- Goodrich Pond Tributary (1)
- Newell Street Bridge (7)
- Newell Street Parking Lot Footbridge (8)
- Lyman Street Bridge (7)
- Elm Street Bridge (7)
- First Pomeroy Avenue Bridge (7)
- West Branch Confluence (7)
- Holmes Road Bridge (13)

- Adjacent to Joseph Drive (7)
- Holmes Road WWTP (7)
- New Lenox Road Bridge (7)
- Headwaters to Woods Pond (7)
- Upstream of Woods Pond Dam (7)
- Schweitzer/Lenoxdale Bridge (7)

BBL obtained a total of 120 split samples for laboratory analysis. All 120 samples were analyzed for total PCBs, POC, TSS, and chlorophyll *a*, while 17 of these samples were also analyzed for dissolved PCBs and TOC. Water temperature, conductance, and pH were measured and recorded during these collection activities.

1.1.1.5 2000 Sampling

BBL conducted monthly water column sampling at the following seven locations (number in parentheses represents total number of samples collected):

- Hubbard Avenue Bridge (24)
- Dawes Avenue Bridge (12)
- Holmes Road Bridge (12)
- New Lenox Road Bridge (12)
- Headwaters to Woods Pond (12)
- Schweitzer/Lenoxdale Bridge (12)
- Division Street Bridge (12)

A total of 96 surface water samples (including duplicates) were collected and analyzed for total PCBs, POC, chlorophyll *a*, and TSS.

In addition, sampling was conducted upstream and downstream of the Unkamet Brook Confluence to supplement the results of previous sampling events. Two surface water samples were collected (one upstream and one downstream) in May 2000. Samples were analyzed for total and dissolved PCBs.

1.1.1.6 2001 Sampling

Between January and December 2001, BBL conducted monthly water column sampling at the following eight locations (number in parentheses represents total number of samples collected):

- Hubbard Avenue Bridge (24)
- Dawes Avenue Bridge (9)
- First Pomeroy Avenue Bridge (3)
- Holmes Road Bridge (12)
- New Lenox Road Bridge (12)
- Headwaters to Woods Pond (10)
- Schweitzer/Lenoxdale Bridge (12)
- Division Street Bridge (12)

A total of 94 surface water samples (including duplicates) were collected and analyzed for total PCBs, POC, chlorophyll *a*, and TSS. In addition, conventional water quality parameters were measured.

1.1.1.7 2002 Sampling

Between January and November 2002, BBL conducted monthly water column sampling at the following 12 locations (number in parentheses represents total number of samples collected):

- Hubbard Avenue Bridge (22)
- Upstream of Unkamet Brook (4)
- Unkamet Brook (4)
- Downstream of Unkamet Brook (4)
- Newell Street Bridge (4)
- Lyman Street Bridge (4)
- First Pomeroy Avenue Bridge (11)
- Holmes Road Bridge (11)
- New Lenox Road Bridge (11)
- Headwaters to Woods Pond (11)
- Schweitzer/Lenoxdale Bridge (11)
- Division Street Bridge (11)

A total of 108 surface water samples (including duplicate samples) were collected and analyzed for total PCBs, POC, chlorophyll *a*, and TSS. In addition, conventional water quality parameters were measured in the field.

1.1.2 Suspended Solids Harvesting

On behalf of GE, suspended solids harvesting was conducted to aid in understanding the movement of suspended particulates and associated PCBs within the water column of the Housatonic River. PCB transport can occur as a result of partitioning from the sediment bed to the water column (dissolved flux) or as a result of resuspension and transport (particulate flux). As explained in the *MCP Supplemental Phase II Scope of Work and Proposal for RCRA Facility Investigation of Housatonic River and Silver Lake* (Phase II SOW/RFI Proposal) (BBL, 1994a), resuspension of sediment (particularly during high-flow events) is a critical mechanism governing PCB transport in the Housatonic River.

Therefore, sampling of suspended sediments commenced at four key locations (Newell Street Bridge, the first Pomeroy Avenue Bridge, New Lenox Road Bridge, and Woods Pond Headwaters) in October 1995. In November 1995 and November 1996, suspended sediment sampling was conducted at the same four locations with the addition of a Schweitzer/Lenoxdale Bridge location. A total of 31 suspended sediment samples were collected and analyzed for PCBs, TOC, and grain size. Surface water samples were collected at the same times and analyzed for PCBs and TSS.

1.1.3 Woods Pond Sediment Traps

As part of the suspended sediment and PCB transport investigations, BBL placed three sediment traps in Woods Pond in October 1994. In August 1995, sampling of the sediment traps was attempted with varied success.

Only one of the three sediment traps was successfully sampled, since one had been lost and the other was displaced from its original position and was thus compromised. A sample of the captured sediment and a duplicate sample were analyzed for PCBs, TOC, and grain size.

1.1.4 High-Flow Sampling

On behalf of GE, LMS collected water column samples during two high-flow sampling events in 1991 (41 samples), four high-flow events in 1992 (118 samples), and two high-flow events in 1993 (58 samples) at Great Barrington, Massachusetts and downstream locations in Connecticut. Depth-integrated water column samples were collected as part of the Connecticut Cooperative Agreement between GE and CDEP to help verify/validate information related to fate and transport modeling. High-flow events were defined as flows greater than or equal to 1,000 cubic feet per second (cfs) at the Great Barrington USGS gage. All samples were analyzed for PCBs, TOC, dissolved organic carbon (DOC), and TSS (LMS, 1994).

In November 1995, January 1996, and May 1996, BBL collected samples during three high-flow events as part of the Housatonic River MCP Supplemental Phase II Investigation. Consistent with the 1991-1993 LMS investigations, high-flow conditions were defined as flows greater than or equal to 1,000 cfs at Division Street in Great Barrington, Massachusetts (location of the USGS gage). Water column monitoring was conducted at 12 locations during the November 1995 sampling event and at 13 locations during the 1996 sampling events between the Hubbard Avenue Bridge (Pittsfield, Massachusetts) and the Division Street Bridge (Great Barrington, Massachusetts). A total of 40 water column grab samples were collected at one-half the water depth and analyzed for PCBs (total and filtered) and TSS.

1.1.5 Housatonic River High-Flow Sediment Loading Study

BBL collected daily water column composite samples between March and May 1997 and in May 1998 to provide suspended solids data in support of the Housatonic River high-flow sediment loading study. The daily composite samples were collected by an automated TSS sampler at several locations along the Housatonic River and at select tributaries downstream of the USGS gaging station at Coltsville, Massachusetts.

During the 1997 sampling events, automated TSS samplers were placed and composite samples were collected from the following seven sampling locations (number in parentheses represents total number of samples collected):

- Hubbard Avenue Bridge (75)
- West Branch Confluence (68)
- Sackett Brook (76)
- Headwaters to Woods Pond (87)
- Woods Pond Dam (81)
- Rising Pond Dam (72)
- Konkapot River (82)

During the 1998 sampling event, automated TSS samplers were placed and composite samples were collected from the seven locations sampled in 1997, with the addition of a sampling location at the Bulls Bridge Dam. The sampling locations and total number of samples collected are summarized below (number in parentheses represents total number of samples):

- Hubbard Avenue Bridge (13)
- West Branch Confluence (13)
- Sackett Brook (13)
- Headwaters to Woods Pond (13)
- Woods Pond Dam (13)
- Rising Pond Dam (12)
- Konkapot River (13)
- Bulls Bridge Dam (12)

Each sample collected represents a daily composite sample of 24 discrete samples collected at a rate of approximately one sample per hour. All composite samples were analyzed for TSS.

1.1.6 EPA Monthly Water Column Monitoring and Storm Flow Sampling

To support the data collection needs for hydrodynamic modeling, water quality modeling, and risk assessments, Weston (on behalf of EPA) conducted surface water sampling on a monthly basis between August 1998 and September 1999 and sampled specific storm flow events between May and December 1999 to provide data on general water quality and suspended sediments.

1.1.6.1 Monthly Water Column Monitoring

Weston collected monthly surface water samples at 17 locations along the Housatonic River between the Crane Paper Company (Dalton, Massachusetts) and the Schweitzer/Lenoxdale Bridge. Sampling, filtration, and analysis methods were based on those developed for the Hudson River (TAMS Consultants, Inc. and Gradient Corporation, 1993). Surface water samples were analyzed for PCBs (filtered and unfiltered), solids (total suspended and total dissolved), organic carbon (TOC and DOC), Appendix IX constituents, and various other field parameters (see Weston, 2002 Section 2.3.1.1 for a complete list). In addition, beginning in 1999, analyses were conducted for PCB congeners. Of the 270 proposed surface water samples, 253 samples were collected for chemical analysis (Weston 2002).

1.1.6.2 Storm Flow Sampling

Storm flow sampling was conducted between May and December 1999 to provide suspended solids information, PCB, and water quality data for modeling efforts. Water and suspended sediment data were used to assist in the determination of resuspension and redistribution of PCB-containing sediment and the effects of storms on water quality and hydrodynamics. Weston conducted storm flow sampling at three primary locations: Pomeroy Avenue Bridge (River Mile [RM] 135.7), New Lenox Road Bridge (RM 129.2), and Woods Pond Dam (RM 124.4) with the objective of harvesting suspended sediments from the water column for chemical analysis. In addition, water samples were collected from five secondary locations (Hubbard Avenue Bridge, Unkamet Brook, West Branch Housatonic River, Sackett Brook, and Roaring Brook) to measure suspended solids between the Hubbard Avenue Bridge (RM 140.6) and Woods Pond Dam (see Weston, 2000 Section 5.3.2 for locations). Water samples were analyzed for PCBs (total, Aroclors, and congeners for both filtered and unfiltered), TSS, organic carbon (TOC, POC, and DOC), and various other field parameters. Harvested suspended sediment samples were analyzed for grain size, total PCBs (< 250 millimeters [mm]), and TOC.

Between May and September 1999, storm flow sampling was conducted at the following eight locations (number in parentheses represents total number of samples):

- Hubbard Street Bridge (196)
- Unkamet Brook (184)
- Pomeroy Avenue Bridge (430)
- West Branch Confluence (205)
- New Lenox Street (540)
- Roaring Brook (178)
- Sackett Brook (163)
- Woods Pond Footbridge (577)

A total of 2,473 water samples were collected for laboratory analyses during the 1999 storm flow sampling (see Weston, 2002 Section 2.3.4.1 for a list of specific analyses).

Between May and September 1999, storm flow sampling was also conducted at the following three locations for suspended solid samples (number in parentheses represents total number of samples):

- Pomeroy Avenue Bridge (35)
- New Lenox Street (35)
- Woods Pond Footbridge (29)

A total of 99 samples were collected for laboratory analyses during the 1999 storm flow sampling (see Weston, 2002 Section 2.3.4.1 for a list of specific analyses).

1.1.7 EPA Discrete River Sampling

In addition to monthly (or biweekly) water column monitoring, EPA also conducted a discrete sampling program between 1998 and 2001. Discrete sampling was conducted to support individual programs that required particular types of data from specific locations (Weston, 2002). Typically, data were collected to address identified data gaps and to improve the overall utility of the data set for use in achieving data quality objectives (Weston, 2002). Specifically, discrete surface water samples were collected for the purposes of ecological risk endpoints (i.e., sediment toxicity, mussel exposure), long-term remediation monitoring, or other non-routine surface water sampling. Data collection activities, tasks, and programs completed by EPA were documented in EPA's *Supplemental Investigation Data Report* (SI Data Report) (Weston, 2002).

1.1.8 Modeling/Fate and Transport-Related Investigations

EPA/GE conducted a PCB partitioning study and EPA conducted a bed load sampling study to support its modeling efforts. These studies are described in the subsections below.

1.1.8.1 2001-2002 EPA/GE PCB Partitioning Study

PCB sorption in the Housatonic River was investigated through a joint EPA/GE field sampling and analysis program conducted during the fall of 2001 and spring of 2002. This program consisted of sampling and analysis

to evaluate the PCB and TOC phase distribution in surface sediments (and associated pore water) and surface water (including suspended matter). The sediment/pore water sampling consisted of:

- Collection of approximately 50 sediment cores from within Reaches 5 and 6 and sectioning the 0- to 6-inch segments of these cores;
- Extraction of the pore water by centrifugation followed by high pressure filtration; and
- Analysis of congener-specific PCBs and TOC for the sediment and pore water samples.

The surface water sampling was conducted in three events, covering low, moderate, and high-flow conditions. Samples were collected at the Pomeroy Avenue Bridge, New Lenox Road Bridge, and Woods Pond Footbridge, and were prepared as follows:

- Large volume (27 liter [L]) samples were collected from the River with a peristaltic pump;
- Samples were pressure filtered to separate the dissolved and particulate phases; and
- Both the filtrate and filter residues were analyzed for congener-specific PCBs and TOC.

Surface water sampling was conducted for three different events covering low-flow (October 2001), moderate-flow (April 2002), and high-flow (June 2002) conditions. The daily average flow measured at the Coltsville gage for these events was 25, 230, and 330 cfs, respectively, with respective peak flows of approximately 300 and 440 cfs during the moderate- and high-flow events.

1.1.8.2 Bedload Sampling Study

EPA sampled bed load (i.e., coarse grained sediment being transported by the River current near the sediment-water interface) during a storm event in May 2002. Ten cross-channel composite samples were collected at the Pomeroy Avenue Bridge and submitted for PCB, TOC, and grain size analyses. Water column samples were also collected at the same times, and were analyzed for TSS, PCBs, and TOC.

1.1.9 Investigation of Other Hazardous Constituents

In addition to the assessment of PCBs in the water column of the Housatonic River, several investigations were conducted to evaluate the presence and extent of non-PCB hazardous constituents in the Housatonic River water column. In 1991, surface water sampling for non-PCB hazardous constituents was conducted by Blasland & Bouck as part of the MCP Phase II water column investigation, and in 1995 by BBL as part of the MCP Supplemental Phase II/RFI activities.

During the 1991 investigation, surface water sampling was conducted upstream of, adjacent to, and downstream of the GE facility in Pittsfield, Massachusetts. Water column samples were collected during both low-flow and high-flow conditions and analyzed for Appendix IX+3 constituents. A total of 14 surface water samples were collected during the 1991 activities and analyzed for PCBs, Appendix IX+3 volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and inorganics.

These results were originally reported in the *Interim Phase II Report/Current Assessment Summary* (Interim Phase II Report/CAS; Blasland & Bouck, 1991), along with an assessment of the hazardous constituents detected that may be related to releases from the GE facility. In addition, an evaluation was performed to determine which constituents posed potential health or environmental concern and therefore warranted further downstream water column sampling. The evaluation in the Interim Phase II Report/CAS concluded that none of

the constituents detected in the water column (aside from PCBs) are of potential health or environmental concern (Blasland & Bouck, 1991); therefore, no other "target constituents" were identified.

In response to comments from the Massachusetts Department of Environmental Protection (MDEP) (which disagreed in part with the evaluation provided in the Interim Phase II Report/CAS and a re-analysis presented in the addendum to that report), further water column sampling and Appendix IX+3 analysis were performed in 1995 as part of the MCP Supplemental Phase II/RFI activities.

As part of the 1995 activities, surface water samples were collected by BBL from eight River locations, upstream of, adjacent to, and downstream of the GE facility in Pittsfield during low-flow (March 1995) and high-flow (June 1995) conditions. A total of 16 samples were collected during the 1995 sampling activities and analyzed for PCBs, TSS, Appendix IX+3 VOCs, SVOCs, and inorganics.

Detailed information on the water sampling discussed above is provided in the *Supplemental Phase II/RCRA Facility Investigation Report* (1996 RFI Report; BBL, 1996).

1.1.10 Physical Parameter Data Collection during 2000-2001 Largemouth Bass Study

On behalf of GE, R2 Resource Consultants, Inc. (R2) collected water temperature, DO, and pH data from locations along the Housatonic River as part of a largemouth bass reproduction and population structure study conducted during 2000 and 2001 (R2, 2002). In 2000, measurements of DO concentrations, pH, conductivity, and water temperature were collected using hand-held digital meters at 13 locations along the River. In addition, continuous water temperature recorders were installed at each of the 13 locations and used from May through September 2000. In 2001, temperature recorders were installed at 12 locations from late March or mid-April to mid-October. Nine continuous DO recorders were deployed in three backwater areas (one unit in the main channel and two within the backwater in each area) in June 2001 and maintained through mid-October 2001. These recorders measured DO, as well as water temperature and pH.

1.2 Sediment Investigations

This section summarizes the recent and historical sediment investigation programs conducted in the Housatonic River.

1.2.1 CAES Sediment Study

CAES, in cooperation with CDEP and USGS, performed a detailed study of the sediments in portions of the Housatonic River in Connecticut and, to a lesser extent, Massachusetts after the initial identification of PCBs in the River sediments. Conducted between 1979 and 1982, the study was designed to assess the extent of PCBs in the River system and "to determine the mass of PCBs in the bottom sediments of the Housatonic River and determine the rate of transport of suspended sediment and PCBs down the river" (Frink et al., 1982). During this joint effort by CAES, USGS, and CDEP, 104 surficial sediment samples and 49 sediment cores were collected from 148 locations in the Housatonic River between the GE facility in Pittsfield, Massachusetts and the mouth at Long Island Sound. In areas where bottom sediments were coarse or thin, surficial sediment samples were collected using a Ponar grab sampler or Eckman dredge, resulting in the collection of the upper 3 to 6 inches of sediment. In areas where sediments were characterized as fine and thick, sediment cores were collected via piston or gravity core sampler. Sediment cores were generally sectioned into 6-inch increments to

the bottom of the core (core depths ranged from 6 to 66 inches), and samples were analyzed for PCBs and TOC. A total of 152 surficial sediment samples (i.e., upper 6 inches) were analyzed for PCBs; CAES analyzed 99 surficial sediment samples and USGS analyzed 81 surficial samples for total PCBs (28 samples were independently analyzed by both groups). A total of 174 sediment core samples (of various depth increments) were analyzed for PCBs; USGS analyzed 147 sediment core samples and CAES analyzed 32 core samples (five core sections were analyzed by both). In addition, CAES analyzed 29 core samples and 92 surficial samples for TOC; USGS analyzed 87 core samples and 60 surficial samples for TOC.

A more detailed description of the sampling events and results can be found in *Polychlorinated Biphenyls in Housatonic River Sediments in Massachusetts and Connecticut: Determination, Distribution, and Transport* (Frink et al., 1982).

1.2.2 Stewart Study

In accordance with a 1981 Consent Order issued by MDEP and EPA, GE commissioned Stewart to conduct an extensive study of the presence and distribution of PCBs within the sediments of the Housatonic River system. As part of the 1982 Stewart study, initial review of aerial photographs and topographic maps resulted in the selection of 36 major sediment sampling stations between Center Pond in Dalton, Massachusetts and the Connecticut state border. The stations were chosen to be representative of the various physical characteristics found in the Housatonic River.

After establishing the 36 sampling stations, the entire River area was methodically examined, probed, and/or sonar-scanned for the purpose of further characterizing the River sediment. As a result of this study, 226 substations were established to represent distinct sediment accumulation areas within the 36 sampling stations. One or more sediment cores were collected in 16-centimeter (cm) increments from the 226 sediment sampling substations, resulting in the collection of 892 sediment samples for PCB and grain size analyses.

The Stewart studies are described in more detail in Sections 4.2 and 4.3.2 of the Interim Phase II Report/CAS (Blasland & Bouck, 1991).

1.2.3 LMS Impoundment Study

In October 1986, on behalf of GE, LMS collected one sediment core from each of six locations including Falls Village Impoundment, Bulls Bridge Impoundment, Route 133 Bridge, Shepaug Dam, Route 84 Bridge, and immediately upstream of the dam at Stevenson, Massachusetts. Sediment cores, ranging in depth from 7 to 31 inches, were sectioned into 1-inch increments, resulting in 100 samples for PCB and TOC analyses. The results of these samples were used to assess transport and distribution of PCBs within these impounded areas.

The LMS impoundment investigation is described in more detail in Section 4.3.3 of the Interim Phase II Report/CAS (Blasland & Bouck, 1991).

1.2.4 MCP Phase II Investigation

In 1990, GE entered into a Consent Order with MDEP to further investigate the nature and extent of PCB contamination within the Housatonic River. This agreement led to the development of a MCP Phase II Investigation, which was conducted by Blasland & Bouck on behalf of GE.

Prior to performing MCP Phase II field sampling activities, a thorough site reconnaissance was conducted in 1990 to assess the then-current state of sediment depositional areas for comparison to assessments developed during prior investigations. At 32 sampling transects established from just upstream of the GE facility to Woods Pond, sediment was probed and cores were collected at one to nine equidistant locations across the River width. At each of the core collection locations, water depth, sediment depth penetrated, sediment depth recovered, and field core description were recorded.

The objective of the 1990 sediment survey was to supplement the extensive existing database generated during the Stewart studies and to attempt to confirm the distribution of PCBs in the portion of the Housatonic River between Pittsfield and Rising Pond. After reviewing the Stewart sediment data, 39 core locations previously sampled by Stewart (in addition to the 32 transect core locations mentioned above) were selected for re-sampling as part of the MCP Phase II investigation. The core locations were selected from those found in the Stewart study to have yielded core samples with PCB concentrations in excess of 50 milligrams per kilogram (mg/kg). Between October and November 1990 and January and February 1991, 39 sediment cores were collected. At each core location, water depth, sediment depth, length of recovered sediment, and a visual description of the sediment core were recorded. Sediment cores were sectioned into 6-inch increments to a depth below the level of the previously identified PCB "hot spot" concentrations (identified in the Stewart study) and then into 1-foot increments to the end of the core, resulting in 213 samples for chemical analysis. Sediment samples were analyzed for PCBs and TOC (analysis was held on 29 samples).

In addition to PCB analysis, another objective of the MCP Phase II Investigation was to determine the presence, if any, of other hazardous constituents in River sediments and to identify which of these constituents could be considered "target" constituents (i.e., constituents that are of potential health or environmental concern) potentially related to releases from the GE facility. Nine core samples were collected in 1990 and 1991 by Blasland & Bouck from two locations in Rising Pond and nine locations in the River between the Hubbard Avenue Bridge and Elm Street Bridge. Recovered cores ranged in length from 0.95 feet to 1.7 feet. The entire core was composited, thoroughly mixed, and analyzed for Appendix IX+3 constituents. The evaluation of these data is presented in Section 4.4.3 of the Interim Phase II Report/CAS (Blasland & Bouck, 1991).

As a result of the Appendix IX+3 constituent evaluation, it was determined that additional sampling downstream of the GE facility was necessary, since the samples contained relatively low PCB levels and may not have reflected good sediment depositional areas. Therefore, in 1992, two additional locations were sampled between the Silver Lake Outlet and Elm Street Bridge, resulting in three sediment samples (including one duplicate) for the analysis of Appendix IX+3 constituents. Sediment samples were analyzed from the 11- to 16-inch (one sample) and 2- to 8-inch (one sample and duplicate) depth intervals.

In 1992, additional upstream sampling was conducted to further define upstream and/or background levels of inorganic compounds to compare with downstream sediment concentrations and to aid in identifying "target" inorganic constituents. Four locations were sampled between the Center Pond and Hubbard Avenue Bridge, one sample per location, for analysis of Appendix IX+3 metals. Samples were generally collected from the upper 6 inches of sediment, the exception being a single sample collected from the 0- to 16-inch depth interval.

Additional information from the MCP Phase II Investigation can be found in the Interim Phase II Report/CAS (Blasland & Bouck, 1991) and the addendum to that report (Blasland & Bouck, 1992a).

1.2.5 GZA Rising Pond Sediment Characterization Study

In 1991, a sediment sampling program was conducted by GZA GeoEnvironmental, Inc. (GZA) and GE (with Blasland & Bouck oversight) to identify the potential presence of chemicals in Rising Pond as a result of releases from the GE facility. The purpose of the investigation was to identify any impacts that sediment quality might have on management options for the Rising Pond Dam. Sediment core samples were collected from 33 locations in Rising Pond to depths of 3 feet to 4.5 feet below the sediment/water interface. A total of 78 sediment core section samples were collected from the 33 locations in Rising Pond and screened for VOCs using a photoionization detector. Based on the screening results, certain samples were selected for further analyses. Analyses conducted on the sediment samples based on the screening results included: VOC analysis (seven samples), total petroleum hydrocarbon (TPH) analysis (18 samples), and eight Resource Conservation and Recovery Act- (RCRA-) regulated metals (17 samples). In addition, PCB analysis was conducted on 63 sediment samples from 10 core locations.

Additional information regarding the results of the MCP Phase II Investigation can be found in Sections 4.3.5 and 4.4.2 of the Interim Phase II Report/CAS (Blasland & Bouck, 1991).

1.2.6 MCP Supplemental Phase II Investigation

The data obtained as part of the MCP Phase II Investigation and prior Housatonic River investigative efforts addressed many of the MCP Phase II requirements and EPA Permit goals as they related to PCBs. However, additional investigative activities were necessary to address either specific MDEP/EPA concerns, or to satisfy data needs previously identified in the *Proposal for the Preliminary Investigation of Corrective Measures for Housatonic River and Silver Lake Sediment* (PICM Proposal; Canonie Environmental, 1995) related to the assessment of various potential remedial approaches to the sediments of the Housatonic River. In response, the following activities were proposed and conducted in 1994 and 1995 as part of the MCP Supplemental Phase II Investigation implemented by GE and BBL.

1.2.6.1 Field Reconnaissance/Sediment Probing/Visual Characterization

Pursuant to Section 2.2.3.1 of the Phase II SOW/RFI Proposal (BBL, 1994a), sediment reconnaissance/probing activities were conducted in October 1994 to provide additional information related to sediment accumulation/deposition areas between the GE facility and Woods Pond. As part of these activities, the River was divided into seven River reaches. Six of these designated River reaches (excluding Woods Pond) were further subdivided into 36 subreaches. Within these 36 subreaches, sediments were physically probed and visually characterized. This activity included visual identification of sediment depositional environments and sediment probing to measure the extent, thickness, and type of various sediment deposits. It also included visual identification of aquatic vegetation, water depths, and accessibility from shore. Sediment depositional environments were characterized as backwater, channel, terrace, or aggrading bar deposits. A total of 221 locations were probed and classified during this portion of the investigation.

Additional information on the field reconnaissance/sediment probing/visual characterization investigation is provided in Section 2.2.3.1 of the Phase II SOW/RFI Proposal (BBL, 1994a).

1.2.6.2 Sediment Sampling to Further Delineate Horizontal and Vertical Extent of PCBs

The sediment reconnaissance/probing data was used to select additional sediment sampling locations to further define the presence of PCBs in sediments where such data were considered limited. In 1994, cores were collected from 25 locations between the GE facility and New Lenox Road and sectioned into 6-inch increments, resulting in a total of 174 sediment samples that were analyzed for PCBs. In addition, 51 samples (core lengths ranging from the top 1.5 feet to 4.5 feet) were selected from 48 core locations and analyzed for oil and grease and TOC.

In addition, due to an unusually high PCB concentration measured during the 1994 sediment sampling activities near the Dawes Avenue Bridge, four additional core locations were sampled in close proximity to further evaluate the presence of PCBs at that location. A total of seven sediment samples were analyzed for PCBs from the four core locations.

As part of the MCP Supplemental Phase II Investigation, BBL conducted additional sediment sampling in Rising Pond. Sampling was conducted at three locations previously sampled by GZA in 1991. At these locations, GZA identified the presence of PCBs at a depth of 4 feet. Therefore, to further delineate the vertical extent of PCBs, sediment samples were analyzed from the 4- to 4.5-foot and 4.5- to 5.0-foot (one location) and 4- to 4.5-foot depth intervals (one location), resulting in three sediment samples for PCB analysis (sediment could not be recovered at depths greater than 4 feet at one location).

Lastly, sediment samples were collected from core locations co-located with biota collection sites. Additional fish samples (young-of-year [YOY] bluegill, largemouth bass, and perch, respectively) were collected during MCP Supplemental Phase II/RFI activities from three locations along the Housatonic River (near New Lenox Road Bridge, Woods Pond, and near the Connecticut border). Due to the large amount of sediment data available for Woods Pond, and limited data collected near New Lenox Road Bridge and the Connecticut border, a total of seven surficial sediment samples (four near New Lenox Road and three near the Connecticut border) were collected from the upper 6 inches and submitted for PCB and TOC analyses.

Additional information on this investigation is provided in the 1996 RFI Report (BBL, 1996).

1.2.6.3 Grain Size versus PCBs and Oil and Grease

As part of the MCP Supplemental Phase II/RFI program, sediment sampling and analysis activities were performed to identify any potential correlation between sediment PCB concentrations and oil and grease concentrations. The information obtained was intended for use in estimating the performance of several potential treatment technologies as described in the PICM Proposal (Canonie Environmental, 1995).

Samples were collected between June 1994 and December 1995 from four reaches previously defined in the PICM Proposal (GE facility to the Confluence, Confluence to New Lenox Road, New Lenox Road to Woods Pond Headwaters, and Woods Pond) (Canonie Environmental, 1995). Two composite samples were collected from each of the four designated River reaches. Core depths ranged from 1.5 to 5 feet. Prior to chemical analysis, each sample was separated by particle grain size into three categories: larger than a No. 10 sieve (coarse sands and gravel), smaller than a No. 10 sieve but larger than a No. 200 sieve (medium to fine sands), and smaller than a No. 200 sieve (silts and clays). A total of 43 samples were analyzed for PCB and 18 samples were analyzed for oil and grease.

Additional information and results of the analysis are provided in Section 3.2.5 of the 1996 RFI Report (BBL, 1996).

1.2.6.4 Evaluation of Historic Sedimentation Rates

The MCP Supplemental Phase II/RFI program included an evaluation of the historical sedimentation rates between the GE facility and the Woods Pond Dam using geochronological dating analyses. These efforts, conducted in November and December 1994, included a two-phased approach. The initial phase (or screening phase) included the collection of 44 sediment cores. The locations of these sediment cores were selected based on the 1994 sediment reconnaissance/probing activities described previously. Sediment cores were sectioned into 1-inch intervals and submitted to the lab for analysis. Various 1-inch segments of each core were analyzed for Cs-137 and Be-7 to generally classify the depositional chronology and identify the maximum depth of Cs-137 presence. Typically, the 0- to 1-inch, 5- to 6-inch, 11- to 12-inch, and 17- to 18-inch core segments were analyzed (38 cores), with the 23- to 24-inch and 28- to 29-inch segments analyzed from six cores. The screening phase resulted in 188 sediment samples for geochronological dating analysis.

Based on the results of the screening phase, 26 of the previous 44 core locations were selected for more detailed analysis. At each of these locations, a second sediment core was collected in July 1995 and sectioned into the 0- to 0.5-inch interval and 1-inch increments to the bottom of the core. Between one and 10 sections from each sediment core were analyzed, resulting in 155 sediment samples for PCB, Cesium-137 (Cs-137), Beryllium-7 (Be-7), and TOC analyses. Data from these analyses were evaluated to estimate approximate rates of sedimentation and to evaluate whether PCB-containing sediments had been buried over time through the deposition of progressively cleaner sediments.

A more detailed description of the collection and analysis activities is presented in Section 3.2.6 of the 1996 RFI Report (BBL, 1996).

1.2.6.5 Sediment Investigations in the Connecticut Portion of the Housatonic River

Pursuant to a 1992 Cooperative Agreement between GE and CDEP, GE collected sediment samples at 55 stations between Great Barrington, Massachusetts and the Stevenson Dam in Connecticut during 1992 and reported the results to CDEP and EPA in February 1994. The purpose of these sampling activities was to evaluate trends in sediment PCB concentrations and develop a more up-to-date sediment characterization in this portion of the River for the fate and transport model being developed by LMS as part of the Cooperative Agreement.

Sediment samples collected at the 55 locations were analyzed as follows:

- At 42 stations, the top 3 inches of each core were composited and submitted for PCB and TOC analyses; 11 of the samples were also analyzed for bulk density and particle size.
- At seven stations, the top 3 inches of each core were sectioned into 1-inch increments; each increment sample was analyzed for PCB and TOC.
- A the remaining six stations, the entire length of sediment cores collected were sectioned into 1-inch intervals, resulting in 119 samples for PCB, TOC, and Cs-137 analyses.

Results from the 49 cores where just the top 3 inches were analyzed were used to provide a more up-to-date sediment characterization for LMS's fate and transport model, while the full core analyses were used to evaluate historical sedimentation rates.

Additional information concerning the sediment investigation in the Connecticut portion of the Housatonic River is provided in Section 3.2.7 of the 1996 RFI Report (BBL, 1996).

1.2.6.6 Investigations of Other Hazardous Constituents

Prior to the MCP Supplemental Phase II/RFI program, several investigations were conducted to assess the presence and extent of non-PCB hazardous constituents in the Housatonic River sediment bed. As previously noted in Section 1.2.4, sediment sampling for non-PCB hazardous constituents was conducted in 1990 and 1991 as part of the MCP Phase II sediment investigations, and samples were analyzed for Appendix IX+3 metals in 1992. These results were originally reported in the Interim Phase II Report/CAS (Blasland, & Bouck, 1991), along with an assessment of which hazardous constituents may be related to releases from the GE facility.

In response to comments from MDEP (which disagreed in part with the evaluation provided in the Interim Phase II Report/CAS), further sediment sampling and Appendix IX+3 analyses were performed in 1994 as part of the MCP Supplemental Phase II/RFI program. Sediment samples were collected from eight locations upstream of, adjacent to, and downstream of the GE facility, resulting in eight samples for PCB, Appendix IX+3 SVOC, and polychlorinated dibenzodioxin/polychlorinated dibenzofuran (PCDD/PCDF) analyses. Sediment samples were generally collected from the upper 20 inches of sediment, with the exception being two samples analyzed from the 2- to 8-inch and 11- to 16-inch depth intervals.

In July 1995, BBL, on behalf of GE, conducted further upstream sediment sampling for PCDD/PCDF analyses. The sample locations corresponded with locations previously sampled in 1992 for Appendix IX+3 metals. In addition, two sediment samples were collected upstream of the GE facility along the Unkamet Brook. All sediment samples were submitted for PCDD/PCDF analyses.

A more detailed description of the sampling activities and analyses is provided in Section 3.2.8 of the 1996 RFI Report (BBL, 1996).

1.2.7 MCP Supplemental Phase II - 1996 Discrete Sediment Sampling

Between May and June 1996, BBL, on behalf of GE, collected 380 discrete sediment samples in the Housatonic River. Within the Rest of River, 289 sediment samples were collected; all 289 were analyzed for PCBs, and 99 of the 289 were also analyzed for TOC. Between the Confluence and Woods Pond Headwaters, 226 samples were collected, and another 63 samples were collected in Woods Pond.

1.2.8 GE Sediment Coring Program

Between December 1997 and March 1998, BBL, on behalf of GE, conducted sediment core sampling and analysis in the Housatonic River to provide sediment data required for calibration of the sediment fate and transport models under development for the River. Sediment texture and bathymetry surveys conducted during August and September 1997 were used to develop the sample and analysis plan. The coring program consisted of three efforts:

- Surface sediment coring;
- Cs-137 coring;
- Bulk sediment cores; and
- Cohesive sediment erosion tests.

Each element is described in more detail below.

1.2.8.1 Surface Sediment Coring

The surface sediment survey provided surface sediment PCB information for comparison with historical data. Cores were collected from five to 10 sampling stations along select transects concentrated within the backwaters of the impoundments downstream of Woods Pond. Cores were segmented into 0- to 2-cm and 2- to 16-cm segments and composited in the field to yield a total of two samples per transect. Samples were analyzed for PCBs (as Aroclors) and TOC.

1.2.8.2 Cs-137 Coring

The Cs-137 coring program provided information on the depositional history of PCBs within several Housatonic River impoundments including Rising Pond, Falls Village Dam impoundment, and Bulls Bridge Dam impoundment. Two 4-inch-diameter cores were collected from each area and segmented in the field into 1-cm segments within the upper 5 cm and into 2-cm segments through the remaining length of the core. Analyses were conducted in phases, as only those cores with interpretable Cs-137 were analyzed for PCBs. As part of the first phase of analysis, the surficial 1-cm segments (five per core) and every third or fourth 2-cm segment for the full length of the core were submitted for Cs-137 and Be-7 analysis. Based on the results of the Cs-137 results, select core segments were submitted for Aroclor PCB, TOC, moisture content, and bulk density analyses in the second phase.

1.2.8.3 Bulk Sediment Cores

Bulk sediment cores provided data on bulk sediment qualities for calibration of the sediment transport model. Five cores were collected from the backwaters of each of the following dams: Woods Pond Dam, Columbia Mill Dam, Willow Mill Dam, Glendale Dam, Rising Pond Dam, Falls Village Dam, and Bulls Bridge Dam. In addition, 10 cores were collected from the meandering channels including the reaches of the River between Dawes Avenue Bridge and Woods Pond Headwaters, as well as between the Division Street Bridge and Falls Village Dam. Bulk sediment cores were segmented to yield a 0- to 8-cm core segment for analysis of sediment grain size, bulk density, and TOC.

1.2.8.4 Cohesive Sediment Erosion Tests

GE conducted a field study during June 1997 to measure the resuspension properties of cohesive sediments collected from the impoundments associated with Woods Pond, Columbia Mill, Willow Mill, Glendale, Rising Pond, Falls Village, and Bulls Bridge Dams. A portable resuspension device, commonly referred to as a shaker, was used to measure the erosion properties of 42 surficial sediment cores collected from the impoundments.

1.2.9 EPA Systematic Sediment Sampling

In 1998 and 1999, Weston, on behalf of EPA, conducted systematic sediment sampling along the five designated Rest of River reaches to provide information for the human health and ecological risk assessments and modeling study. Systematic sampling refers to a sampling strategy in which samples are collected at regular intervals over the study area. The interval distance for each reach was determined based on several factors, including expected contaminant concentrations, distance from sources, and length of River reach (Weston, 2000).

Prior to sediment core collection activities, Weston conducted a comprehensive survey of sediment depth to aid in defining the sediment profile within each reach, and assist in determining ore collection locations. Core collection locations were placed at approximately three equidistant points along each transect, unless the review of the probing information warranted otherwise.

Within the Rest of River, sediment cores were generally sectioned into the 0- to 6-inch, 6- to 12-inch, 12- to 18-inch, and 18- to 24-inch depth intervals prior to laboratory analysis. Sediment samples were analyzed for PCBs (total and Aroclors), grain size, and TOC. In addition, approximately 10% of samples were analyzed for Appendix IX constituents and 2% were analyzed for Appendix IX organophosphate pesticides and herbicides (Weston 2002).

Between the Confluence and Woods Pond, a total of 38 transects were established at approximately 1,500-foot intervals, resulting in the collection of 544 sediment samples for chemical analysis. To help define the channel geometry (needed in the modeling study), an additional 16 transects were established perpendicular to the River across the entire width of the 10-year floodplain, which resulted in the collection of 250 sediment samples for laboratory analysis. Samples collected within this reach were used in support of the human health and ecological risk assessments and modeling study.

Within Woods Pond, a total of 19 sediment cores (77 samples) were collected to supplement previously reported data from cores collected by BBL. One transect was established in the pond to help define the channel geometry information needed in the modeling study. Sediment cores were collected every 100 feet across this transect, down to a depth of 2 feet. Samples collected in Woods Pond were used in support of the human health and ecological risk assessments and modeling study.

From Woods Pond Dam to Rising Pond, a total of 41 transects were established at approximately 2,500-foot intervals, resulting in the collection of 294 sediment samples for chemical analysis. Samples collected within this reach were used in support of the human health and ecological risk assessments.

Additional information on EPA's systematic sediment sampling program can be found in the SI Data Report (Weston, 2002).

1.2.10 EPA Discrete Sediment Sampling

In addition to the systematic sampling program, EPA also conducted a discrete sampling program between 1998 and 2002. Discrete sampling refers to "random, judgmental, or focused samples collected at distinct locations" (Weston, 2000). To support the human health and ecological risk assessments and modeling study, sediment samples were collected from specific locations (e.g., aggrading bars, backwater areas), specific habitats, or areas

associated with frequent human exposure (e.g., canoe launch). Further, EPA performed periodic cross-section surveys to evaluate changes in sediment and bed morphology. Each specific program is described in the SI Data Report (Weston, 2002). The data associated with these analyses is provided in the EPA database.

1.2.11 EPA Modeling-Related Sediment Studies

To assess changes in River channel morphology, EPA conducted periodic cross-section surveys along nine transects within Reaches 5A and 5B that were originally surveyed in 1999. Bed elevations at various points across the channel were measured at each transect location, at three additional times: September 2001, April 2002, and June 2002.

1.3 Floodplain and Riverbank Soil Investigations

Several studies have been conducted since 1988 to document the nature and extent of PCBs in floodplain and riverbank soils adjacent to the Housatonic River. The following sections summarize each of the major studies performed. Sections 1.3.1 through 1.3.5 describe work performed by BBL on behalf of GE; Section 1.3.6 describes EPA's efforts.

1.3.1 DeVos Property Investigation (1988-1989)

The DeVos property is located immediately south of New Lenox Road (in Lenox, Massachusetts, RM 129.2), along the eastern bank of the River channel. Due to concerns related to the possible presence of PCBs, sampling of the floodplain soils on the DeVos property was performed by BBL on behalf of GE in 1988 and 1989. A total of 52 locations were sampled; at each location, floodplain soils were sampled at 0- to 4-inch and 4- to 8-inch depths and analyzed for PCBs and percent solids. Additional detail about the study and its results are provided in the Interim Phase II Report/CAS (Blasland & Bouck, 1991).

1.3.2 MCP Phase II Investigation (1990-1992)

Since PCBs were detected in the floodplain soil samples of the DeVos property and historical flood events on the Housatonic River may have produced conditions conducive to the transport of PCB-containing sediments to the floodplain, a floodplain investigation was conducted during 1990 as part of the MCP Phase II Investigation (Blasland & Bouck, 1991). The investigation was conducted by BBL on behalf of GE to provide a more complete characterization of the nature and extent of PCB distribution in floodplain soils.

Eleven floodplain transects (designated FP1 through FP11) were identified for sampling and analysis. Ten of the 11 transects, FP2 through FP11, are located within the Rest of River reach between the Confluence and the Connecticut border. (Transect FP1 is located upstream of the GE facility in Coltsville, Massachusetts.) The sampling locations downstream of the Confluence were selected based on a review of historical aerial photographs, existing floodplain data, and topographic mapping, as well as information available from previous sampling of River depositional areas. The locations were selected to represent the various types of River conditions present.

At each sampling transect downstream of the Confluence, soil samples were collected at locations selected by field personnel based on the morphological characteristics of the floodplain. Sampling locations were generally

distributed over the entire transect, with locations closer together near the riverbank and gradually becoming farther apart at greater distances from the River. A minimum of 10 sampling locations was specified for each transect. A total of 114 sampling locations were established at the 10 transects downstream of the Confluence. At each sampling location, soil cores were collected to a depth of 1 foot and sectioned into two 6-inch increments (0 to 0.5 foot and 0.5 to 1 foot). A total of 227 floodplain soil samples were collected at the 114 locations positioned along the 10 transects, and analyzed for PCBs and percent solids.

Additional sampling was performed at two of the 10 transects (FP2 and FP7) in July 1992 to better define the lateral and vertical extent of PCBs at these locations. A total of 36 samples were collected from nine locations along the two transects. Samples were collected at 6-inch intervals to a depth of 2 feet and analyzed for PCBs and TOC.

Details of this floodplain soil investigation are contained in the Interim Phase II Report/CAS (Blasland & Bouck, 1991) and the addendum to that report (Blasland & Bouck, 1992a).

1.3.3 Floodplain Properties - Short-Term Measures Evaluation (1992-1994)

BBL conducted several additional floodplain soil sampling events on behalf of GE as part of MDEP-required activities to evaluate the need for short-term measures (STMs) at specific tax parcels or properties within the floodplain. These activities included the collection of approximately 89 additional floodplain soil samples on various occasions between August 1992 and November 1993 at properties located between the Confluence and the Connecticut border that were identified as areas of likely human use (Blasland & Bouck, 1992a, 1993; BBL, 1994a, b). Samples were sectioned into 6-inch increments to a maximum depth of 3.5 feet and analyzed for PCBs, TOC, and percent solids. The majority of samples submitted for analysis were surficial soil samples collected from the 0- to 6-inch depth interval. These studies concluded that PCB concentrations greater than 1 mg/kg generally occurred within the approximate 10-year floodplain.

In May 1994, a total of 14 composite samples of floodplain soil were collected from certain wildlife habitat areas between New Lenox Road and Woods Pond for analysis of PCBs. Additionally, a total of 12 floodplain soil samples were collected from certain additional areas between New Lenox Road and Woods Pond in June 1994 for analysis of PCBs.

Detailed discussions of the results of the floodplain properties STM evaluations are contained in the following reports:

- *Summary of Housatonic River Floodplain Property Sampling and Analysis* (Blasland & Bouck, 1992b);
- *Report on January 1993 Housatonic River Floodplain Property Sampling and Analysis* (Blasland & Bouck, 1993);
- *Housatonic River Floodplain Properties – Results of Supplemental Site Characterization Sampling* (BBL, 1994b); and
- *Evaluation of the Terrestrial Ecosystem of the Housatonic River Valley* (ChemRisk, 1994).

1.3.4 MCP Supplemental Phase II/RFI Program (1994-1995)

A MCP Supplemental Phase II/RFI was conducted between 1994 and 1995 for the Housatonic River and Silver Lake. As part of this investigation, floodplain soil sampling was conducted by BBL on behalf of GE at previously established soil transects (FP2 through FP11) as well as at several new transects to further define

PCB concentrations within other areas of the Rest of River between the Confluence and the Connecticut border. A total of approximately 430 samples were collected from 22 transects (10 existing and 12 new transects). The new floodplain sampling transects included three transects between the existing transect FP4 and Woods Pond Dam (designated FP4A, FP6A, and FP7A), four transects immediately upstream of each of the first four existing dams downstream of the Woods Pond Dam (designated FP8A [Columbia Mill Dam], FP9A [Willow Mill Dam], FP9C [Glendale Dam], and FP9D [Rising Pond Dam]), and five transects below Woods Pond (designated FP9B [Stockbridge Golf Course], FP10A, B, and C [Searles Middle School], and FP10D [Sheffield Plain]). The 1996 RFI Report (BBL, 1996) identifies transect locations. As directed by EPA and MDEP, floodplain samples were also collected from a backwater area to the west of transect FP6A. Samples were collected in 6-inch depth increments to a maximum depth of 6.5 feet and analyzed for PCBs and percent solids, and generally each of the 0- to 6-inch samples was also analyzed for TOC.

As part of further investigations to define the extent of PCBs in Housatonic River floodplain soils, a number of residential properties were sampled in 1995. These properties consisted of two parcels located in the Rest of River reaches: along Holmes Road in Pittsfield (Parcel J5-2-11) and along New Lenox Road in Lenox (Parcel 29-5). Each property was sampled at numerous locations and the samples were analyzed for PCBs and, in some cases, TOC. A total of 24 samples were collected in 6-inch increments to a depth of 1 foot at each location.

Revised HEC-2 modeling was used as part of the investigation to estimate the approximate extent of the flood recurrence interval associated with the previously defined 1 mg/kg PCB isopleth between the GE facility and Woods Pond Dam. Results of the modeling effort showed that PCB concentrations of 1 mg/kg or greater were generally limited to within the approximate 5-year floodplain, and that elevated PCB concentrations are typically confined to areas close to the River and at similar elevations. However, exceptions were observed at locations behind bridges and in topographic irregularities where local geography interfered with flood flow conveyance. Downstream of the Woods Pond Dam, the extent of the PCB-impacted floodplain soil was determined to be very limited, generally found only in close proximity to the River. The results of these studies are summarized in detail in the 1996 RFI Report (BBL, 1996).

1.3.5 Additional Floodplain Properties Soil Sampling (1997-1998)

As part of the continued investigation of the floodplain characteristics, approximately 360 samples from six floodplain parcel properties (parcels 8-38, 8-48, 33-1-2A, J3-2-2, J3-2-3, and J6-3-1; see BBL, 1996 for locations) between the Confluence and the Connecticut border were collected by BBL on behalf of GE in 1997 and 1998. Soil samples were collected in 6-inch depth increments to a maximum of 5.5 feet and analyzed for PCBs and percent solids. Results are reported in monthly status reports submitted to EPA and MDEP.

1.3.6 EPA Supplemental Investigation Riverbank and Floodplain Soil Sampling (1998–2002)

Beginning in 1998, EPA began the most extensive effort to date to fully characterize conditions in Housatonic River floodplain and bank soils. One of the objectives of EPA's SI was to define the nature and extent of PCBs and other constituents in the Rest of River and associated floodplain, and to further delineate pathways of contaminant migration. According to the *Supplemental Investigation Work Plan* (SI Work Plan) (Weston, 2000), limited floodplain soil PCB results were available in Reaches 5 through 9, considering the extent and diversity of the areas being investigated. The data generated are to be used for the site ecological risk assessment to define the concentrations of constituents in various habitats as well as to define the concentrations of constituents available to human exposure. In addition, the data will be used to validate and calibrate site models.

The majority of the sampling was conducted by EPA contractors (e.g., Weston). On behalf of GE, split samples were also collected by BBL at selected sampling locations. The sampling approach included the collection of samples from historical locations as well as additional locations and was generally conducted out to the 10-year floodplain. The sampling approach was designed to optimize the effort, and included both systematic (i.e., collection of data at regularly spaced intervals) and discrete sampling (i.e., focused on specific areas) to address specific data quality objectives (Weston, 2000).

In general, soil samples were collected at 6-inch intervals to varying depths depending upon the sampling location. All soil samples collected were analyzed for PCBs and percent solids; the majority of the samples were analyzed for total PCBs and PCB Aroclors by a field laboratory. Ten percent of the soil samples were analyzed by a fixed laboratory for PCB Aroclors, and 135 soil samples were also analyzed for PCB congeners (and homologs) by a fixed laboratory. Ten percent of the soil samples were analyzed for a modified list of Appendix IX compounds, including SVOCs, organochlorine pesticides/PCBs, PCDDs/PCDFs, and inorganics. Additionally, 2% of all samples were analyzed for a modified list of Appendix IX organophosphate pesticides and herbicides.

TOC and grain size analyses were performed on approximately 10% of the riverbank and floodplain soil samples and, as necessary, when the field sampling teams encountered changes in soil type and organic matter at riverbank and floodplain locations.

1.3.6.1 Systematic Sampling

Systematic sampling (i.e., sampling along regularly-spaced transects) was performed during EPA's 1998-2002 effort to further characterize the Housatonic River floodplain conditions. For each River reach, regularly-spaced transects were sampled to characterize the entire reach. Systematic sampling along transects was performed in all reaches, except Reaches 8 and 9 (only discrete sampling was performed in Reaches 8 and 9, which extend from Rising Pond to the Connecticut border).

For floodplain soil samples, systematic sampling was conducted through Reach 7. Samples were collected within the 10-year floodplain using a series of transects that were perpendicular to the River channel. The distance between transects increased moving downstream, as the chemical concentrations were expected to decrease with increasing distance from the Source Reach (Reach 3, between the Newell Street Bridge to the Lyman Street Bridge) (Weston, 2000).

Each transect was positioned perpendicular to the River channel, with sampling starting from one side of the floodplain across the River channel to the opposite side of the floodplain. On a typical transect, nine samples were collected from three locations in the floodplain on each side of the River, with the samples located between the riverbank and the outer extent of the 10-year floodplain at equal distances. Therefore, floodplain transects consisted of six sampling locations, each sampled at three depths (i.e., 0 to 6 inches, 12 to 18 inches, and 24 to 30 inches below ground surface [bgs]). Three to nine samples (from one to three locations) were also targeted from each riverbank (where a distinct riverbank was present) (Weston, 2000). Riverbank sampling locations included the bottom of the bank (toe of slope), mid-bank (terrace), and the top of bank. Similar to the floodplain, samples were typically collected in alternating 6-inch depth intervals to a depth of 30 inches (i.e., 0 to 6 inches, 12 to 18 inches, and 24 to 30 inches bgs).

Due to the broad floodplains characteristic of the area, only a few sizable riverbanks exist in Reach 5 (Confluence to Woods Pond). Therefore, sampling of riverbank soils was conducted only when they were

encountered during the floodplain sampling program. Systematic riverbank soil sampling was not proposed for Reach 6 (Woods Pond) since the area is characterized by a broader floodplain with low banks. Additionally, systematic bank sampling along transects was not proposed for Reaches 7 through 9 based on historical data, which indicated that the area downstream of Woods Pond contained relatively low PCB concentrations.

1.3.6.2 Discrete Sampling

Discrete sampling of soils was performed by Weston on behalf of EPA during the SI (between 1998 and 2002) to characterize specific areas or to support specific data quality objectives where relatively few data were available from previous studies. The sampling involved collecting soil samples at distinct locations, including a number riverbank and adjacent floodplain soil samples.

For floodplain and riverbank soils, discrete sampling was conducted for all Reaches in the Rest of River area (between Reach 5 and Reach 9). Discrete floodplain and riverbank sampling was conducted in association with specific biological studies or areas of frequent human exposure (Weston, 2000). These areas included recreational, residential, agricultural, and commercial/industrial areas in the 10-year floodplain. For riverbank soils at these public access areas, up to two samples (0 to 6 inches and 6 to 12 inches) were collected at each location. Data collection activities and programs completed by EPA were documented in EPA's SI Data Report (Weston, 2002).

1.3.6.3 EPA Modeling-Related Soil Studies

2000-2002 Toe Pin Measurements

Groups of toe pins were installed by EPA in October 2000 in the riverbank at five locations within Reaches 5A and 5B. The toe pins were used to measure bank locations at four different times during an approximately 20-month period, with the last data collected in June 2002.

2001-2002 River Meander Study

To evaluate movement of riverbanks, EPA conducted surveys along River meanders in Reaches 5A and 5B in November 2001 and June 2002. Bank location data (i.e., top- and bottom-of-bank) were collected along 15 riverbank stretches that ranged in length from approximately 140 feet to 525 feet. In addition, aerial photographs of the River taken in 1952, 1978, 1990, and 2000 were ortho-referenced in an attempt to produce comparable digital shorelines for each of these periods.

1.3.6.4 Vernal Pool Sampling

In support of the ecological risk assessment, approximately 56 temporary pools located in the floodplain in Reaches 5 and 6 were sampled between 1998 and 2002. Depending on the pool size, approximately two to five samples from 6-inch depth intervals were collected at each sampling location, resulting in the collection of 441 samples for chemical analysis.

1.4 Biological Investigations - Description of Sampling and Analysis Activities

Many studies have been conducted on the Housatonic River to evaluate the concentrations of PCBs and other constituents in fish, small mammals, birds, invertebrates, and other types of organisms. This section provides an overview of the sampling and analysis activities performed for the Rest of River area.

1.4.1 Housatonic River Fish Sampling

Fish sampling has been conducted in both the Massachusetts and Connecticut portions of the Housatonic River for more than 20 years. The program description, target species, and analytical parameters for each of the sampling events are discussed below, and summarized in Table 6-1.

1.4.1.1 GE/Stewart Studies (1980, 1982)

Stewart collected fish during 1980 and 1982 from eight sampling stations along a 70-mile reach of the Housatonic River in Massachusetts (from the headwaters of Center Pond in Dalton to the Massachusetts/Connecticut state line). The findings of these two sampling efforts were presented in the *Housatonic River Study: 1980 and 1982 Investigations* (Stewart, 1982). The objective of the 1980 fish collections was to collect four principal sport fish indigenous to the Housatonic River study area (i.e., trout, bass, yellow perch, and sunfish) (Stewart, 1982). In keeping with the requirements of the Consent Decree, the 1982 collection objective was altered to include fish, frogs, and other types of aquatic life that may be consumed by humans (Stewart, 1982). As such, the 1982 sampling included several additional fish species (brown bullhead, chain pickerel, crappie, and rock bass). A total of 721 fish samples were collected during the 1980 and 1982 studies. Of these fish, 382 were analyzed as 40 composite samples, and the remaining 339 fish were archived for possible analysis at a later date. Each of the fish samples was analyzed as skin-on or skin-off fillets (depending on the species) for total PCBs and percent lipids by IT Laboratories. The Stewart study also included the analysis of six fish samples (four from Massachusetts and two from Connecticut) for PCDFs. Analyses of the PCDFs were conducted by University of Umea in Sweden (Stewart, 1982). In 1982, Stewart also conducted a split sampling program with EPA for fish collected from Connecticut.

1.4.1.2 GE/BBL MCP Phase II Fish Sampling (1990)

BBL collected fish samples in November 1990 as part of the MCP Phase II Investigation. These efforts were designed to generate data for a screening-level study to supplement the previous (1980 and 1982) studies by Stewart Laboratories. The sampling locations included Woods Pond and Rising Pond, and target species were largemouth bass, yellow perch, and brown trout. The total number of samples collected included 18 fish from Woods Pond and 10 fish from Rising Pond. Each of the samples was processed as individual skin-on fillets, and analyzed for total PCBs and percent lipids. In addition, the one bass and one brown trout from each location that exhibited the highest total PCB concentrations were analyzed for PCDDs/PCDFs. Results of the 1990 fish sampling were presented in the Interim Phase II Report/CAS (Blasland & Bouck, 1991).

1.4.1.3 GE/BBL Tributary Fish Sampling (1995)

In 1995, BBL conducted limited fish sampling for two Housatonic River tributaries, the Green River and the Williams River, and a nearby reference location (Laurel Lake). A total of four to five fish were collected from each location, including two rock bass and two brown trout from the Green River, two smallmouth bass and two brown trout from the Williams River, and five largemouth bass from Laurel Lake. All samples were analyzed for total PCBs and percent lipids as skin-on/scales-off fillets. Results are presented in the 1996 RFI Report (BBL, 1996), monthly status reports submitted to EPA and MDEP, and the GE database.

1.4.1.4 GE/BBL YOY Fish Sampling (1994 – 2002)

BBL has conducted YOY fish sampling biannually from 1994 to 2002. The YOY sampling involved the collection of three species: largemouth bass, yellow perch, and bluegill (or pumpkinseed, if bluegill were not found). Seven composite samples (five to 25 fish per composite) of each species were collected from sampling locations HR2 (located south of New Lenox Road), Woods Pond, and HR6 (in Massachusetts, just north of the Connecticut border). The composite YOY fish samples were analyzed as whole-body samples for total PCBs and percent lipids. Results for all four years are presented in monthly status reports submitted to EPA and MDEP and are also contained in the GE database. Data from the 1994 and 1996 investigations are presented and discussed in the 1996 RFI Report (BBL, 1996).

1.4.1.5 GE/BBL Supplemental Fish Sampling (1998, 2002)

BBL conducted fish monitoring along several locations of the Housatonic River in November 1998. The fish sampling included three locations: from the Confluence to the Pittsfield WWTP, Rising Pond, and sampling location HR6 (located in Massachusetts, just north of the Connecticut border). Target organisms included in the sampling were bluntnose minnows, brown bullhead, yellow bullhead, yellow perch, pumpkinseed, and bluegill. Samples were processed as individual skin-on fillets and whole-body, as well as whole-body composites, and analyzed for total PCBs and percent lipids. Results are presented in monthly status reports submitted to EPA and MDEP, and are contained in the GE database.

In 2002, GE collected largemouth bass to evaluate the low lipid values reported by EPA from the agency's recent fish tissue samples. Fifteen adult largemouth bass were collected from both Reach 5B (upstream of Woods Pond) and Reach 5 (Woods Pond). The fish were processed as skin-off fillets and offal, and analyzed for PCB congeners and lipid content. During this sampling program, yearling and adult pumpkinseed were also captured; these fish had selected scales removed for age determination, and were released back to the River.

1.4.1.6 GE/ARCADIS Fish Sampling (1999)

ARCADIS conducted a fish sampling program as part of a larger fish reproduction study in 1999. Largemouth bass were collected from four locations in the Housatonic River (Deep Reach, Woods Pond, Rising Pond, the Connecticut border) and from Three-Mile Pond. Five female largemouth bass individual samples were processed as whole body and analyzed for total PCBs and percent lipids. Results are presented in monthly status reports submitted to EPA and MDEP, and are contained in the GE database.

1.4.1.7 EPA/USFWS Fish Sampling (1998 – 2000)

EPA and the U.S. Fish and Wildlife Service (USFWS) conducted a fish sampling program in the Massachusetts section of the Housatonic River in 1998, and to a lesser extent in 1999 and 2000. The details of the fish monitoring program were described in the SI Work Plan (Weston, 2000). The objective of the fish sampling was to characterize biological media to support human health and ecological risk assessments (Weston, 2000). In 1998, the sampling included seven locations, five downstream of the GE facility (including stretches between the Confluence and Woods Pond dam, Rising Pond, and Goodrich Pond), and two reference areas (the East Branch at Dalton and Three-Mile Pond). More than 1,000 fish samples were collected in 1998, and the target species were largemouth bass, yellow perch, brown bullhead, pumpkinseed, bluegill, goldfish, and various minnows (i.e., golden shiner, common shiner, fallfish, and bluntnose minnow). Some smallmouth bass and yellow bullhead were also collected for analysis. Fish samples were processed as either whole body or fillet/offal. The samples were analyzed for PCBs (both Aroclor and congener/homologue analyses), and some of the fish samples were also analyzed for PCDDs/PCDFs and organochlorine pesticides. In 1999, EPA collected additional fish samples for analysis of PCBs, PCDDs/PCDFs, and metals. Samples included largemouth bass from Woods Pond and a reference location (Three-Mile Pond). Again, fish samples were processed as either whole body or fillet/offal. In 2000, EPA collected a single goldfish from Woods Pond and white suckers from Woods Pond and immediately upstream of Woods Pond for PCB analysis.

1.4.1.8 CDEP Fish Sampling (1977 – 1983)

CDEP sampled resident fish at four locations along the Housatonic River from 1977 to 1983. These areas included Bulls Bridge, Cornwall, Lake Lillinonah, and Lake Zoar. Target species varied, and most of the samples were brown trout and smallmouth bass, but other species (e.g., bluegill, chain pickerel, largemouth bass, and rainbow trout) were also retained. Samples were processed as skin-on/scales-off fillets or skin-off fillets and analyzed for PCB Aroclors and percent lipids. GE and BBL reviewed results of these investigations as documented on fish monitoring data sheets obtained from CDEP.

1.4.1.9 GE/ANSP Fish Sampling (1984 - 2000)

Since 1984, the Academy of Natural Sciences of Philadelphia (ANSP) has conducted a biennial monitoring program of PCB concentrations in selected fish in the Connecticut portion of the Housatonic River. The ANSP fish monitoring program is summarized in the document titled *PCB Concentrations in Fishes from the Housatonic River, Connecticut, 1984-2000, and in Benthic Insects, 1978-2001* (ANSP, 2001). The studies from 1994 and earlier were required by the 1990 Housatonic River Cooperative Agreement between CDEP and GE. The studies were continued in 1996 and 1998; in October 1999, a new Housatonic River Follow-up Cooperative Agreement was executed, requiring continuation of biennial biological monitoring studies in 2000, 2002, and 2004. Sampling stations for the ANSP fish monitoring are West Cornwall, Bulls Bridge, Lake Lillinonah, and Lake Zoar. The primary target species were brown trout and smallmouth bass, although in 2000 (at the request of CDEP) bluegill, pumpkinseed, brown bullhead, and yellow perch were collected at Falls Village and Bulls Bridge. The objective of the supplemental sampling was to provide data to assess Connecticut's fish consumption advisory for the Housatonic River (ANSP, 2001). Samples were analyzed as skin-on/scales-off fillets, skin-on/scales-on fillets, or skin-off fillets, depending on the species. Each of the fish samples collected during the ANSP studies was analyzed for PCBs and percent lipids.

1.4.2 Housatonic River Non-Fish Biota Sampling Programs

Historically, fish have been the primary focus of the biota monitoring programs conducted on the Housatonic River; however, over the years data have been collected for biota other than fish. The non-fish biota sampling programs include the collection and analyses of reptiles and amphibians, aquatic and terrestrial invertebrates, aquatic and terrestrial vegetation, aquatic microorganisms, and birds. While the non-fish biota studies are summarized in Table 6-2, these studies are also briefly described below.

1.4.2.1 GE/Stewart Studies (1980, 1982)

The 1980 and 1982 Stewart studies collected non-fish biota samples, including limited numbers of aquatic macrophytes, frogs, and snapping turtles. The data are presented in the report titled *Housatonic River Study: 1980 and 1982 Investigations* (Stewart, 1982), and a brief summary is provided below.

- Aquatic Macrophytes – In 1980, Stewart collected aquatic vegetation from several areas along the Housatonic River, including the East Branch upstream of Newell Street, between the Confluence and Woods Pond, Woods Pond, Woods Pond to Rising Pond, and downstream of Rising Pond. Corresponding sediment samples were taken in association with each vegetation sample. A total of five samples of duck potato and 10 samples of water milfoil and lesser duckweed were analyzed for total PCBs.

- Frogs – In 1982, Stewart collected 12 bullfrogs from Woods Pond. The frogs were combined into a single composite sample and analyzed for total PCBs and percent lipids. The specific sample type (e.g., leg muscle tissue only, whole-body) is unknown.

- Snapping Turtles – In 1982, Stewart collected a single snapping turtle from Woods Pond. The sample was analyzed for total PCBs and percent lipids, although the specific sample type (e.g., muscle tissue only, whole-body) is unknown.

1.4.2.2 GE/BBL Sampling (1992, 1996)

In addition to fish, BBL collected other biota samples from the Housatonic River in 1992 and 1996. These collections consisted of frog samples collected in 1992 and a single algae sample collected in 1996, described below.

- Frogs – In 1992, BBL collected a total of 21 bullfrogs from Woods Pond. Three composite samples of leg muscle tissue (seven frogs per sample) were analyzed for total PCBs and percent lipid. Analyses were conducted by Hazleton Laboratories. Data are presented in the Addendum to the Interim Phase II Report/CAS (Blasland & Bouck, 1992a).

- Algae – In 1996, BBL collected one sample of algae from the River near the former Housatonic Street Bridge Abutment. This sample was analyzed for total PCBs. Data are presented in the 1996 RFI Report (BBL, 1996).

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1.4.2.3 EPA SI Sampling (1998 – 2001)

As part of the SI, EPA conducted numerous biological investigations at various locations along the Housatonic River, including several reference areas. These investigations were completed to support the baseline human health and ecological risk assessments. The sampling details and results (i.e., number of samples and locations, collection methods) are described in the SI Data Report (Weston, 2002). The EPA studies are summarized below.

- Terrestrial Vegetation – In 1998, 1999, and 2000, EPA collected samples from various types of agricultural crops and other types of plants from fields that extended into the floodplain of the Housatonic River. In 1998, EPA collected nine samples of corn along the Housatonic River at the Confluence (Reach 5A), and the samples were analyzed for PCB Aroclors. In 1999, EPA collected corn, squash, and fiddleheads from two sites along the Housatonic River downstream of the GE facility. Twelve corn, nine squash, and two fiddlehead samples were collected from Reach 5A, and eight corn samples and one fiddlehead sample were collected along the River upstream of the Pittsfield WWTP (Reach 5B). Corn samples were processed as either ear or stalk, and squash samples were processed as either flesh or pulp and seeds. These samples were analyzed for PCB Aroclors. In 2000, EPA collected fiddleheads from the two sites sampled in 1999 (Reaches 5A and 5B) as well as the East Branch of the Housatonic River upstream of Newell Street (Reach 1/2). Four samples were collected from Reach 5A, two samples each were collected from Reaches 1/2 and 5B; all were analyzed for PCB congeners. In 2001, EPA collected 11 grass samples from Reach 5B and analyzed them for PCB congeners and PCDDs/PCDFs.

- Aquatic Microorganisms – In 2000, EPA collected composite samples of phytoplankton and zooplankton from Reaches 4, 5, and 6. The samples were analyzed for total PCBs, and a subset of the samples was analyzed for select organochlorine pesticides and PCDDs/PCDFs.

- Aquatic Vegetation – In 2000, EPA collected composite samples of periphyton (from rock and macrophyte scrapings, from the substrate, and from filtered surface water). EPA also collected samples of filamentous algae, macrophytes, and detritus. The samples were collected from several reaches, including the West Branch and Reaches 4, 5A, and 5B. The samples were analyzed for total PCBs, and a subset of the samples were analyzed for select organochlorine pesticides, PCDDs/PCDFs, and other organics.

- Aquatic Macroinvertebrates - In 1999, EPA collected composite samples of stonefly nymphs from four sites (three sites along the Housatonic River downstream of the GE facility and one at a reference area outside the Housatonic River drainage basin). One sample was collected from the East Branch of the River, upstream of Newell Street (Reaches 1 and 2), eight samples were collected from the River between the Confluence and Woods Pond (Reach 5), two samples were collected from the West Branch, and one sample was collected from a reference area. In 2000, EPA collected two composite samples of caddisfly larvae. All stonefly and caddisfly samples were collected from Reach 4 and analyzed for PCB congeners, select organochlorine pesticides, and percent lipids. A subset of the samples was also analyzed for PCDDs/PCDFs.

- Crayfish – In 1999, EPA collected crayfish from three sites, including two sites along the Housatonic River downstream of the GE facility and one reference area outside the Housatonic River drainage basin. Forty samples were collected from the River between the Confluence and Woods Pond (Reach 5). Ten samples each were collected from the West Branch and a reference area. These samples were

processed as individual whole body samples, and analyzed for PCB congeners, select organochlorine pesticides, and percent lipids. A subset of the samples was also analyzed for PCDDs/PCDFs.

- California Black Worms – In 1999, EPA collected worms from four locations along the Housatonic River, including the West Branch, the East Branch upstream of Newell Street (Reaches 1 and 2), the Confluence (Reach 5A), and upstream of the Roaring Brook confluence (Reach 5C). Four composite samples were collected from the West Branch, six from Reaches 1 and 2, 12 from Reach 5A, and eight from Reach 5C. The worm samples were analyzed for PCB congeners.

- Frogs – In 1998, EPA collected one bullfrog sample from the Housatonic River, between the Confluence and Woods Pond. This sample was processed as a whole-body individual and analyzed for PCB congeners, select organochlorine pesticides, percent lipids, and PCDDs/PCDFs. In 1999, EPA collected bullfrogs from various locations along the River, including near the Confluence (three samples), upstream of the Roaring Brook confluence (six samples), the backwater area upstream of Woods Pond (two samples), Woods Pond (six samples), the western half of Woods Pond plus the main channel of the River upstream of the pond proper (three samples), the eastern half of Woods Pond (one sample), and a reference area (11 samples). EPA also collected leopard frogs in 1999 from Reach 5A (12 samples), Reach 5C (eight samples) and the West Branch (four samples). Tissue samples were processed as leg muscle tissue and/or offal, and analyzed for PCB congeners, select organochlorine pesticides, percent lipids, and PCDDs/PCDFs. In 2000/2001, EPA collected wood frog egg masses found in vernal pools in the Housatonic River floodplain as part of the agency's respective reproductive studies. The samples included frogs at various stages of development, including eggs, larvae, tadpoles, and metamorphs. Whole-body samples and composites were analyzed for PCB Aroclors, pesticides, herbicides, SVOCs, PCDDs/PCDFs, and/or polynuclear aromatic hydrocarbons (PAHs).

- Waterfowl – In 1998, EPA collected a total of 45 ducks (40 wood ducks and five mallards) from the Housatonic River and Three-Mile Pond. Eleven ducks (three mallard and eight wood ducks) were collected from the River between the Confluence and Woods Pond (Reach 5), and 14 ducks (two mallard and 12 wood ducks) were collected from Woods Pond (Reach 6). Twenty wood ducks were collected from Three-Mile Pond, which was used as a reference area. Each duck was processed as breast and/or liver tissue. Tissue samples were analyzed for PCB congeners, select organochlorine pesticides, percent lipids, and PCDDs/PCDFs.

- Tree Swallows – EPA conducted a 3-year study on tree swallows from 1998 through 2001. In 1998, EPA collected tree swallows from swallow boxes stationed along the West Branch of the Housatonic River and also between the Confluence and Woods Pond (Reach 5). Pippers and nestlings were collected and processed as breast tissue, and food samples were removed from the swallows' stomachs. Eggs were also collected. The samples were analyzed for PCB congeners, select organochlorine pesticides, percent lipids, PCDDs/PCDFs, and/or metals. In 1999, EPA collected tree swallows from swallow boxes at four sites (three sites along the Housatonic River downstream of the GE facility and one at a reference location outside the Housatonic River drainage basin). Breast samples, eggs, and composite food samples were collected from the River near its confluence with Woods Pond (Reach 5), the East Branch of the River upstream of Newell Street (Reaches 1 and 2), the West Branch of the River, and a reference area. The samples were also analyzed for PCB congeners, select organochlorine pesticides, percent lipids, and/or PCDDs/PCDFs. In 2000, EPA collected tree swallows from swallow boxes at the same four sites sampled in 1999, and the samples again were analyzed for PCB congeners, select organochlorine pesticides, percent lipids, PAHs, and/or PCDDs/PCDFs.

- House Wrens – In 1999, EPA collected five eggs from nest boxes along the Housatonic River between the Confluence and Woods Pond (Reach 5). The eggs were analyzed for PCB congeners, select organochlorine pesticides, and percent lipids.

- Chickadee - In 2000, EPA collected three chickadee egg samples from nests along the Housatonic River between the Confluence and Woods Pond (Reach 5). The eggs were analyzed for PCB congeners and select organochlorine pesticides.

- Small Mammals – EPA collected small mammal samples from Reach 5 in 1998 and 1999. However, the small mammal samples collected in 1998 were not submitted for analyses because the samples were lost due to a freezer failure (Weston, 2002). Small mammals were re-sampled in 1999, and a total of 24 short-tailed shrews and 52 white-footed mice were analyzed for PCBs (Aroclors and congeners) and organochlorine pesticides. A subset of the samples was also analyzed for PCDDs/PCDFs.

1.4.2.4 GE/ARCADIS Sampling (2001)

ARCADIS collected biota samples from the Housatonic River in 2001 as part of larger field studies. These collections consisted of frog and robin samples, described below.

- Frogs – In 2001, ARCADIS collected wood frog tadpoles and wood frog larvae samples from vernal pools in the Housatonic River floodplain. Five composite larvae samples and four composite tadpole samples were analyzed for total PCBs and percent lipid. Analyses were conducted by Northeast Analytical Environmental Lab Services (NAE). Results are presented in monthly status reports submitted to EPA and MDEP, and are contained in the GE database.

- Robins – In 2001, ARCADIS collected 11 robin eggs and 11 nestlings from nests situated in the floodplain between the Confluence of the East and West Branch and Woods Pond. Two eggs and six nestlings were collected from reference areas, which included Peru Wildlife Management Area, Peru State Forest, Middlefield State Forest, October Mountain State Forest, and Hinsdale Flats Wildlife Management Area. Egg and nestling samples were analyzed for total PCBs and percent lipids. Analyses were conducted by NEA. Results are presented in monthly status reports submitted to EPA and MDEP, and are contained in the GE database.

1.4.2.5 CDEP/ANSP Sampling (1978 – 2001)

CDEP and ANSP collected benthic invertebrates and periphyton from locations along the Housatonic River in Connecticut. Results from 1978 through 1991 are presented and discussed in the Interim Phase II Report/CAS (Blasland & Bouck, 1991), while data collected between 1991 and 1995 have been reported separately by ANSP. Results for the entire sampling effort are summarized in *PCB Concentrations in Fishes from the Housatonic River, Connecticut 1984-2000 and in Benthic Insects, 1978-2001* (ANSP, 2001).

- Benthic Invertebrates – CDEP collected benthic invertebrates from various locations along the River in 1978. Two samples of caddisfly larvae and three samples of stonefly larvae were collected and analyzed for total PCBs. Benthic invertebrate sampling of the Housatonic River continued at Cornwall from 1978 through 2001. Forty-four total composite samples of benthic invertebrates (specifically caddisfly, hellgrammite, and stonefly) were collected during a period of 16 years. Caddisfly larvae were collected to represent a typical filter feeding aquatic insect, and hellgrammite larvae and stonefly

nymphs were collected to represent predatory insects. Multiple composite samples were collected and analyzed for PCB Aroclors.

- Periphyton – CDEP collected periphyton (rock scrapings) from various locations along the River in 1978. Three samples were collected and analyzed for PCB Aroclors.

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